



# Fundamental Aeronautics Program

## *Supersonics Project*

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Flight Research and Validation Overview

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DFRC / Aerodynamics and Propulsion Branch

2011 Technical Conference

March 13-15, 2012

Cleveland, Ohio

[www.nasa.gov](http://www.nasa.gov)



## Technical Challenge: Flight Research and Validation (FRV)



### FRV Objectives:

- Increase the Technology Readiness Level (TRL-5+) of promising concepts and technologies through research and validation in the flight environment.
- Development of test techniques and testbeds to more effectively and efficiently test candidate concepts in flight.

### FRV Elements:

- Flight Research
- Flight Test Technique Development
- Testbed Development



# Portfolio: Flight Research and Validation (FRV)



## Flight Research:

Large-scale component or fundamental tests conducted at real conditions and representative systems complexity.



**Channeled Centerbody Inlet Experiment (CCIE)**  
**Supersonic Boundary-Layer Transition Test (SBLT)**  
**External Vision Systems (XVS)**  
**Sonic Boom Cockpit Display (SBCD)**

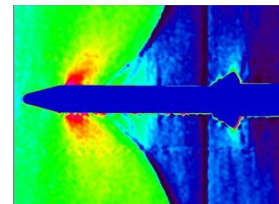
## NRA:



**Eagle Aero Probes (EAP)**

## Flight Test Technique Development:

Development of hardware and methodology to improve current techniques or produce new techniques for in-flight measurement or visualization.



**Airborne Background Oriented Schlieren (AirBOS)**  
**Dynamic Inertia Measurement Technique (DIM)**  
**Air-to-Air Schlieren Imaging System (ASIS)**  
**Advanced In-Flight IR Thermography (AIR-T)**

## Testbed Development:



Develop new in-flight facilities to perform flight research or test technique development.

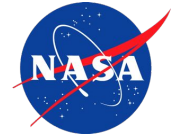


**TG-14**

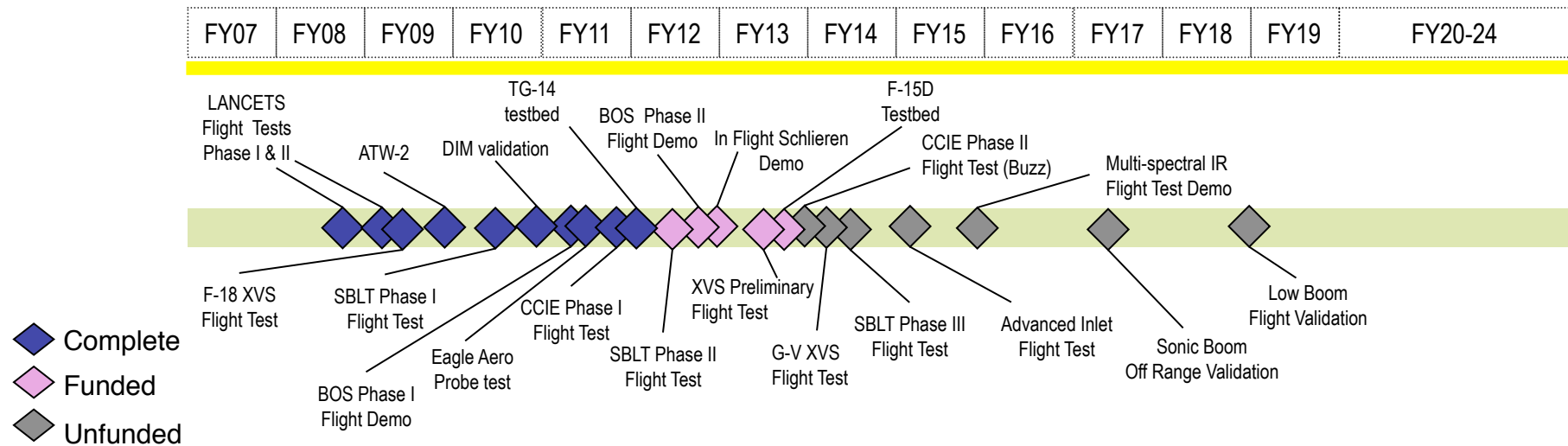


**F-15D**

# Measuring Progress: Flight Research and Validation



## Flight Research: The final exam to test for success.



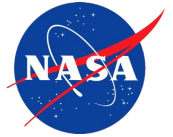
## Recent Progress Toward Meeting Technical Challenge

- Phase I Supersonic Boundary Layer Transition (SBLT) experiment completed
- Phase II SBLT, High Reynolds number laminar flow test article in fabrication
- External vision standards defined
- Flight test of Channeled Centerbody Inlet concept completed
- Flight Demonstration of Background Oriented Schlieren completed
- Eagle Aero Probe validation test completed

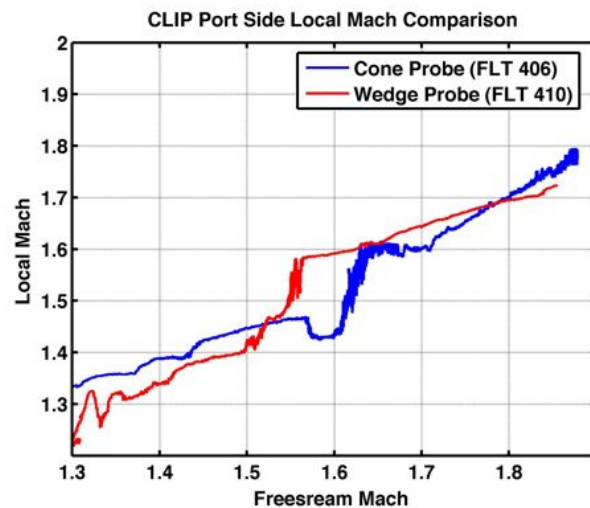


## Key Activity Status:

### NRA- Eagle Aeronautics Shock Wave Probes, EAP



- High accuracy probes for shock wave characterization
  - > local Mach number, flow angle, total pressure and temperature, static pressure and temperature, velocity and speed sound
- Probes and data algorithms validated
- Wind tunnel test completed
- Flight test completed, follow on planned
- Final report written, in publication cycle
- Plan to re-fly probes, including wedge on nose



**Wedge / Conical Probe  
Comparison**



**Wedge and Conical Probes  
Mounted Under F-15B**

## Key Activity Status:

### Channeled Centerbody Inlet Experiment, CCIE

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- Biconic supersonic inlet concept developed by Techland Research via a NASA SBIR contract
  - Inlet design features a unique method of off-design flow matching via movable channels rather than translating centerbody
- Pressure data was collected over a series of Mach numbers and mass flow conditions for two fixed geometry inlet configurations and three fixed nozzle areas used to determine differences between the two (with emphasis placed on distortion) as well as for comparison to CFD predictions
- Presentation on Thursday at 9:30 am (Supersonics Session)



# Key Activity Status: Supersonic Boundary-Layer Transition, SBLT



## Objective:

- Flight research and validation of high Reynolds number transition at supersonic conditions.

## Approach:

- Phase I flight tests of a flat plate test article for calibration of aircraft underside flow field
  - Completed August 2010
- Phase II design and test of high Re No. natural laminar flow test article
  - Phase II test article is being fabricated
  - Fly 3<sup>rd</sup> / 4<sup>th</sup> quarter FY'12

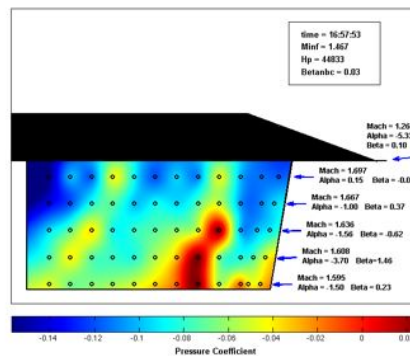


## Significance:

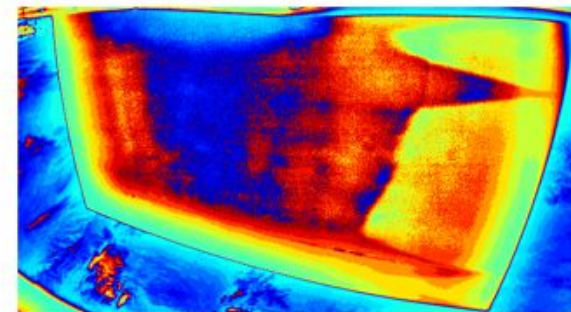
- Validation of design tools for high Reynolds number transition at  $1.0 > M > 2.0$
- Determination of roughness sensitivity for maintenance of laminar flow at these conditions
- Determination of cross flow sensitivity on transition at these conditions



Flat plate test article on F-15



Surface Pressures and  
Upstream Flow Conditions



Infrared Thermography showing  
boundary layer transition

# Key Activity Status: eXternal Vision Systems, XVS



## Objective:

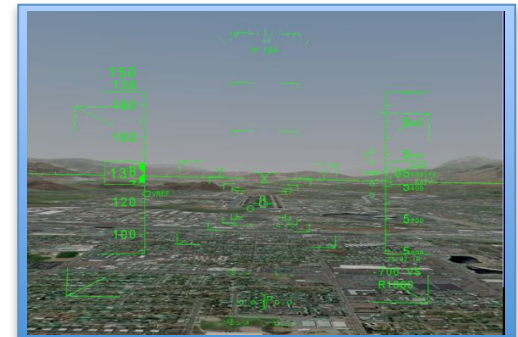
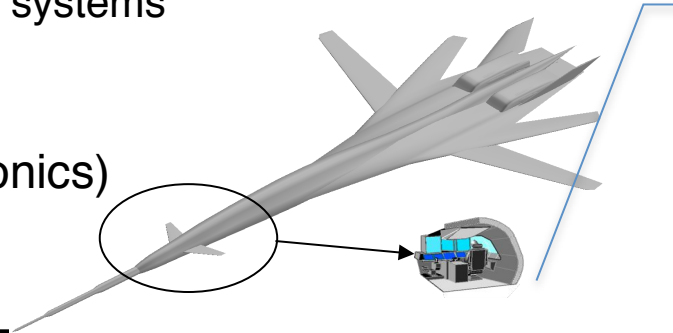
Develop eXternal Visibility Systems (XVS) Technology  
Enabling Replacement of Pilots' Forward View Windows  
- Display, Sensor, And Associated Systems.

## Approach:

Define necessary standards  
Exploit new and complementary technologies  
- Enhanced and synthetic systems

## Presentation:

Thursday 9 am (Supersonics)





# Key Activity Status: Sonic Boom Cockpit Display



## Objective:

To Develop and validate a “Sonic Boom Cockpit Display”

## Approach:

Display provides information to pilots on present and future sonic boom locations and levels to avoid exceeding noise limits

Working in NASA Dryden control room since 2001

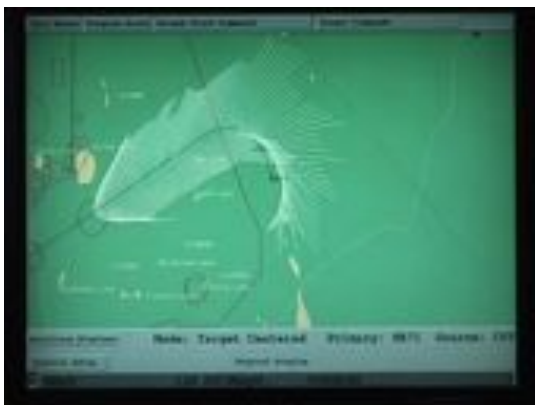
- Integration of aircraft, atmospheric, and terrain data
- Real-time computation of sonic boom impact areas and levels
- Computes limits of airspeed/altitude for Mach cutoff



## NASA Patented Technology

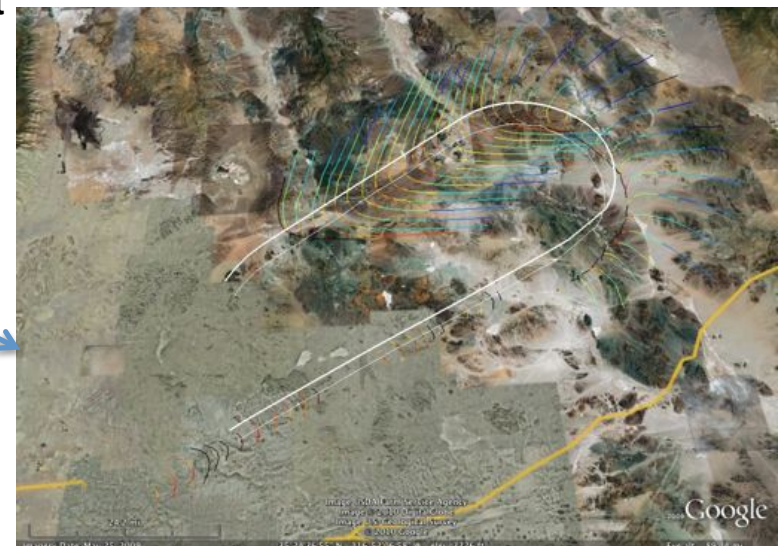
## Current / Future Efforts:

- Extend demonstration into supersonic cockpit
- Predictive feature for future maneuvers
- Use in preflight planning, cockpit, and ground control stations



Improved version

Original version



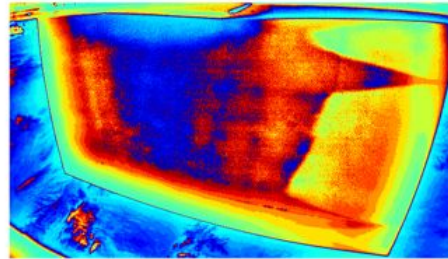
# Key Activity Status: Flight Test Techniques



## Advanced IR Thermography

Increased capability of in-flight IR thermography systems.

- Targeted for boundary-layer transition tests
- Also developing algorithms and methods for image processing



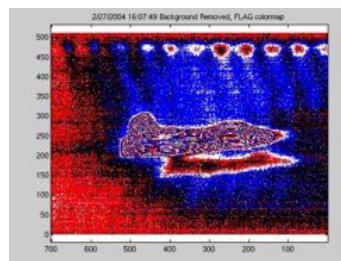
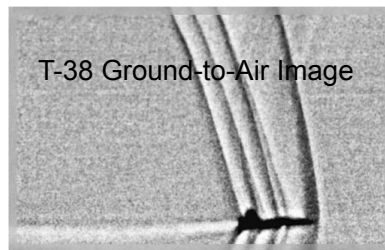
## Dynamic Inertia Measurement

Reduced time and vehicle risk, increased accuracy for measurement of full mass matrix of full scale flight vehicles.



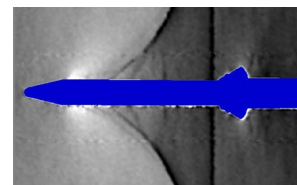
## Air-to-Air Schlieren Imaging System

Obtain high quality Schlieren image with good spatial resolution. Will allow determination of shock location and relative strength in-flight.



## Airborne Background Oriented Schlieren

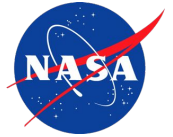
Synthetic Schlieren technique based on the distortion of known background pattern. In compressible fluids the distortion is caused by changes in the refractive index as a result of density gradients.



Gray-scale BOS

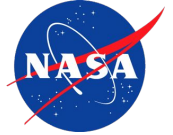


## Key Activity Status: Testbed Development



- **Replacement for F-15B testbed (836)**
  - Dual role for 1 airframe
- **Replacement for one 2-seat F-18 support aircraft**
  - Provides higher Mach chase and probing capability
- **Development as a midfield sonic boom sensor platform**
- **Provides longer endurance and better station keeping than previously used gliders**
- **Low-speed platform for other tests**

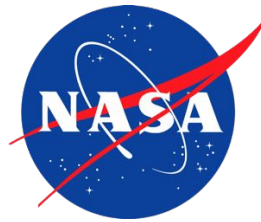




## **Thursday March 15th**

- 9:00 – 9:30 am “External Vision Systems for Supersonic Aircraft”, Mr. Randall Bailey, NASA LaRC
- 9:30 – 10:00 am “Channeled Centerbody Inlet Flight Experiment”, Mr. Clinton St. John, NASA DFRC





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